

750 GeV Resonance in the Dark Left-Right Model

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Abstract

We explain the 750 GeV diphoton resonance in the context of the dark left-right symmetric model. A global symmetry in this model, stabilizes the dark matter and ensures that the scalar couples dominantly to gluons and photons. The branching fraction of the scalar to diphoton is large as a consequence of the symmetries of the theory. The benchmark values assumed to fit the diphoton signal also give the correct relic density of dark matter and muon ($g - 2$). A specific prediction of this model is that the dark matter has a mass of 200 GeV.

Keywords: Left-right symmetry; Dark matter; Muon magnetic moment; Scalar resonance

1 Introduction

A new diphoton excess has been reported by the ATLAS [1] and CMS collaborations [2] in their analysis of $\sqrt{s} = 13$ TeV pp collision. The cross-section of $\sigma(pp \rightarrow \gamma\gamma)$ for the 13 TeV run has been given as the excess of the cross-section in $\gamma\gamma$ channel can be estimated as (6 ± 3) fb (CMS [2]) and (10 ± 3) fb (ATLAS [1]). The excess has taken a wide attention in the community and a wide range of models has been proposed to explain this excess. Since the two photon decay can occur from a spin-0 or spin-2 particle resonance, the models considered of elementary scalars [3–41], composite pseudo-Nambu-Goldstone bosons [42–51], Kaluza-Klein graviton [52, 53] or cascade decays of heavier particles [54, 55]. The effect of 750 GeV resonance on vacuum stability is studied in [56–58]. Previously, the resonant production of (pseudo-)scalars coupled to two photons and gluons in the mass region from 30 GeV to 2 TeV at the LHC has been studied in [59]¹. The resonance must be produced from gg or qq vertices and decay to $\gamma\gamma$ via exotic fermions, gauge bosons or scalars in the loop. It would be of interest to examine the possibility of a 750 GeV resonance in an existing well motivated particle physics model. A well studied generalization of the Standard Model (SM) is the left-right model with the gauge group $SU(2)_L \times SU(2)_R \times U(1)$ and the same fermions content as the SM. In the left-right model, the right handed neutrino would have been a good candidate as a Dark Matter (DM) if it could be made stable against decays via W_R^\pm . To ensure the stability of the dark matter, an extra global symmetry S is imposed in the so called dark left-right gauge model (DLRM) [63, 64]. The spontaneous breaking of $SU(2)_R \times S$ is achieved in such a way as to leave the combination $\tilde{L} \equiv S - T_{3R}$ unbroken. The fermion sector is extended by adding two quarks. The generalized lepton number is $\tilde{L} = 1$ for the SM leptons and $\tilde{L} = 0$ for all other SM particles. To achieve this pattern of symmetry breaking and give masses to the fermions, one adds two doublets to the usual higgs

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¹ A comprehensive check of 750 GeV diphoton resonance models has been performed by implementing them in the SARAH [60, 61] package by Staub et al. [62]

sector of the left-right model. In this model the right-handed gauge boson W_R^\pm has $\tilde{L} = 1$ and this prevent the decay of the right-handed neutrino (n_R) via W_R^\pm and makes the lightest right-handed neutrino a candidate for dark matter [63–65]. It has also been shown that the charged scalars of the triplet higgs of the DLRM model can give an adequate contributions to the muon ($g - 2$).

In this paper, we explain the 750 GeV diphoton excess [1, 2] in the DLRM model. The neutral component (ϕ_R^0) of the right-handed higgs doublet Φ_R is interpreted as the resonance. It can couple to gluons via the exotic quarks (x) and to photons via the same quark, W_R^\pm and right-handed charged scalars ($\Delta_R^\pm, \Delta_R^{\pm\pm}$). Interestingly, in this model ϕ_R^0 (750 GeV) dominantly decays into gluons and photons pairs and this explain the large value of $\Gamma(\phi_R^0 \rightarrow gg)\Gamma(\phi_R^0 \rightarrow \gamma\gamma)/\Gamma_{\text{tot}}$ needed to explain the diphoton signal [1, 2]. The cross-section $\sigma(pp \rightarrow \gamma\gamma)$ depends upon the x Yukawa coupling with ϕ_R^0 , the charged higgs masses $m_{\Delta_R^\pm}, m_{\Delta_R^{\pm\pm}}$, and the quartic couplings f_1, f_2 of $\Phi_R\Phi_R\Delta_R\Delta_R$ interaction. There is a negative contribution to the $\phi_R^0 \rightarrow \gamma\gamma$ amplitude from the W_R^\pm loop, but this is small due to the large W_R^\pm mass. We scan the parameter space of these couplings and masses, which give the cross-section $\sigma(pp \rightarrow \phi_R^0 \rightarrow \gamma\gamma) = 3\text{--}13$ fb. We compute the muon ($g - 2$) where the Δ_R^\pm and $\Delta_R^{\pm\pm}$ contributes in the loop. We find that by taking the masses of the charged scalars $m_{\Delta_R^\pm} \simeq m_{\Delta_R^{\pm\pm}} = 530$ GeV and their Yukawas with μ of the order of unity we get the required Δa_μ of $\sim 3 \times 10^{-9}$. We identify the second generation n_R as the dark matter. With these parameters fixed we find that the correct relic density is obtained by taking the dark matter mass 200 GeV.

The paper is organized as follows: in Sec. 2 we described the dark left-right model. In Sec. 3 we explain the observed diphoton signal in this model. The dark matter aspects and the constraints from muon ($g - 2$) are discussed in Sec. 4 and finally we conclude in Sec. 5.

2 Dark Left-Right Model

We consider the dark left-right gauge model (DLRM) [63, 64] with gauge a group $SU(3)_C \times SU(2)_R \times SU(2)_L \times U(1)$ of the usual left-right model. In DLRM, there is an extra $U(1)$ global symmetry S to ensure that the spontaneous breaking of $SU(2)_R \times S$ leaves the global symmetry $\tilde{L} = S - T_{3R}$ unbroken. Here \tilde{L} is identified as generalized lepton number, with $\tilde{L} = 1$ for the SM leptons, and $\tilde{L} = 0$ for all other SM particles. In this model W_R^\pm also carries a lepton number, which ensures the stability of dark matter. In addition to the SM fermions (shown in Table 1), model contains new neutral lepton (n_R) and exotic quark (x_R). The model also have a new $SU(2)_{L,R}$ singlet quark (x_L). The exotic quark (x_L, x_R), n_R carry the generalized lepton number $\tilde{L} = 1$. This ensures that the Yukawa terms can be written without breaking the global symmetry S . The scalar sector of

Fermion	$SU(3)_c \otimes SU(2)_L \otimes SU(2)_R \otimes U(1)$	S	L
$\Psi_L = (\nu, e)_L$	$(1, 2, 1, -1/2)$	1	$(1, 1)$
$\Psi_R = (n, e)_R$	$(1, 1, 2, -1/2)$	1/2	$(0, 1)$
$Q_L = (u, d)_L$	$(3, 2, 1, 1/6)$	0	$(0, 0)$
$Q_R = (u, x)_R$	$(3, 1, 2, 1/6)$	1/2	$(0, 1)$
d_R	$(3, 1, 1, -1/3)$	0	0
x_L	$(3, 1, 1, -1/3)$	1	1

Table 1: Fermion content of DLRM model.

DLRM consists of a bi-doublet (Φ), two triplets (Δ_L, Δ_R) and two doublets (Φ_L, Φ_R) such as,

$$\Phi = \begin{pmatrix} \phi_1^0 & \phi_2^+ \\ \phi_1^- & \phi_2^0 \end{pmatrix}, \Phi_L = \begin{pmatrix} \phi_L^+ \\ \phi_L^0 \end{pmatrix}, \Phi_R = \begin{pmatrix} \phi_R^+ \\ \phi_R^0 \end{pmatrix} \text{ and } \Delta_{L,R} = \begin{pmatrix} \frac{\Delta_{L,R}^+}{\sqrt{2}} & \Delta_{L,R}^{++} \\ \Delta_{L,R}^0 & -\frac{\Delta_{L,R}^-}{\sqrt{2}} \end{pmatrix},$$

The quantum numbers of scalars under the DLRM gauge group and S are listed in Table 2. As a result of

Scalar	$SU(3)_c \otimes SU(2)_L \otimes SU(2)_R \otimes U(1)$	S
Φ	$(1, 2, 2, 0)$	$1/2$
$\tilde{\Phi}$	$(1, 2, 2, 0)$	$-1/2$
Φ_L	$(1, 2, 1, 1/2)$	0
Φ_R	$(1, 1, 2, 1/2)$	$-1/2$
Δ_L	$(1, 3, 1, 1)$	-2
Δ_R	$(1, 1, 3, 1)$	-1

Table 2: Scalar content of DLRM model. Note that $\tilde{\Phi} = \sigma_2 \Phi^* \sigma_2$.

global symmetry S , not all of the Yukawa terms are allowed. The allowed Yukawa terms are:

$$\bar{\psi}_L \Phi \psi_R, \bar{Q}_L \tilde{\Phi} Q_R, \bar{Q}_L \Phi_L d_R, \bar{Q}_R \Phi_R x_L, \psi_L \psi_L \Delta_L, \text{ and } \psi_R \psi_R \Delta_R, \quad (1)$$

whereas S forbids the Yukawa terms like: $\bar{\psi}_L \tilde{\Phi} \psi_R$, $\bar{Q}_L \Phi Q_R$ and $\bar{x}_L d_R$. So the masses of charged leptons and up-quark come from the vacuum expectation value (vev) $v_2 = \langle \phi_2^0 \rangle$, mass of the down-quark comes from $v_3 = \langle \phi_L^0 \rangle$, mass of the exotic quark comes from $v_4 = \langle \phi_R^0 \rangle$, mass of neutrino comes from $v_5 = \langle \Delta_L^0 \rangle$, and mass of n_R comes from $v_6 = \langle \Delta_R^0 \rangle$. The flavor-changing neutral currents will be absent at the tree level as a result of considered model structure.

The scalar potential with terms allowed by S is of the form,

$$V = \left(m_1^2 \Phi^\dagger \Phi + m_3^2 \Phi_L^\dagger \Phi_L + m_4^2 \Phi_R^\dagger \Phi_R + m_5^2 \Delta_L^\dagger \Delta_L + m_6^2 \text{Tr}(\Delta_R^\dagger \Delta_R) \right) + \Phi_R^\dagger \Delta_R \tilde{\Phi}_R + \Phi_L^\dagger \Phi \Phi_R + \text{Tr}(\tilde{\Phi}^\dagger \Delta_L \Phi \Delta_L^\dagger) + \text{quartic-terms}. \quad (2)$$

The higgs potential leaves the combination $\tilde{L} = S - T_{3R}$ unbroken giving rise to solution $v_1 = \langle \phi_1^0 \rangle = 0$. We will focus on the $SU(2)_R$ higgs structure of DLRM and consider the most general higgs potential containing Φ_R and Δ_R [64],

$$\begin{aligned} V_R = & m_4^2 \Phi_R^\dagger \Phi_R + m_6^2 \text{Tr}(\Delta_R^\dagger \Delta_R) + \frac{1}{2} \lambda_1 (\Phi_R^\dagger \Phi_R)^2 + \frac{1}{2} \lambda_2 [\text{Tr}(\Delta_R^\dagger \Delta_R)]^2 \\ & + \frac{1}{4} \lambda_3 \text{Tr}(\Delta_R^\dagger \Delta_R - \Delta_R \Delta_R^\dagger)^2 + f_1 (\Phi_R^\dagger \Phi_R) \text{Tr}(\Delta_R^\dagger \Delta_R) \\ & + f_2 \Phi_R^\dagger (\Delta_R^\dagger \Delta_R - \Delta_R \Delta_R^\dagger) \Phi_R + \mu (\Phi_R^\dagger \Delta_R \tilde{\Phi}_R + \tilde{\Phi}_R^\dagger \Delta_R^\dagger \Phi_R). \end{aligned} \quad (3)$$

After the electroweak symmetry breaking, the mass matrix of the CP-even neutral scalars contains off-diagonal terms and give as,

$$\mathcal{M}^2 (\text{Re}(\phi_R^0), \text{Re}(\Delta_R^0)) = \begin{pmatrix} 2\lambda_1 v_4^2 & 2(f_1 - f_2)v_4 v_6 + 2\mu v_4 \\ 2(f_1 - f_2)v_4 v_6 + 2\mu v_4 & 2(\lambda_2 + \lambda_3)v_6^2 - \mu v_4^2/v_6 \end{pmatrix}.$$

If we assume a small mixing between ϕ_R^0 and Δ_R^0 by taking $f_1 = f_2$ and $\mu \ll \lambda_1 v_4$, then the lowest mass eigenstate is,

$$m_{H_1}^2 \approx 2\lambda_1 v_4^2, \quad (4)$$

which we identify as 750 GeV resonance observed at LHC. We will now discuss the relevant interactions of $H_1 = \phi_R^0$, which are responsible for various decay modes.

There exists exotic quark (x) in the model, the loop induced process of which can produce ϕ_R^0 through gluon fusion. The ϕ_R^0 can subsequently decay to photons (as shown in Fig. 1) giving rise to the observed diphoton signal. The relevant Yukawa interaction is $\bar{Q}_R \Phi_R x_L$, which translates to $\bar{u}_R \phi_R^+ x_L + \bar{x}_R \phi_R^0 x_L$. The resonance ϕ_R^0 can also decay through W_R^\pm , Δ_R^\pm and $\Delta_R^{\pm\pm}$, by the following interactions,

$$g_R \phi_R^0 W_R^\mu W_{R\nu}, 2v_4 f_1 \Delta_R^+ \Delta_R^- \phi_R^0, \text{ and } 2v_4 (f_1 + f_2) \Delta_R^{++} \Delta_R^{--} \phi_R^0. \quad (5)$$

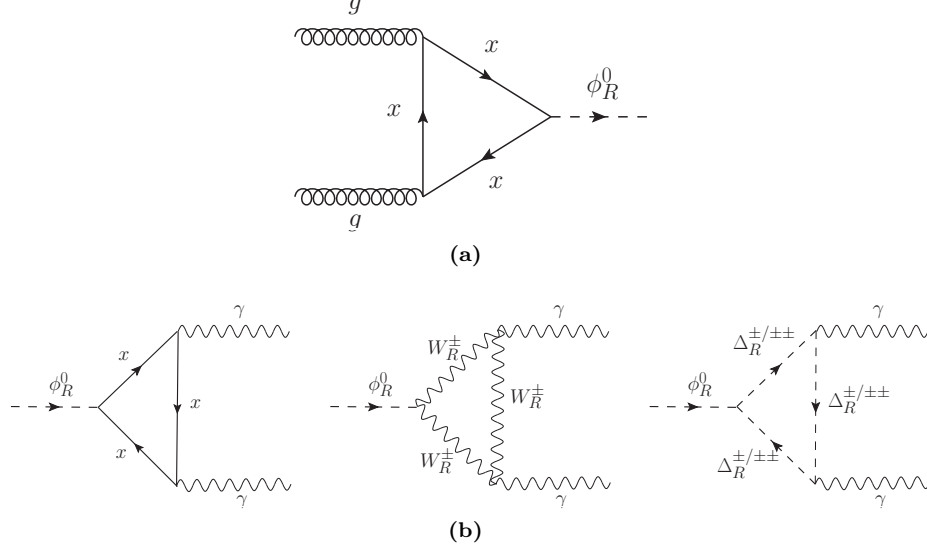


Figure 1: Feynman diagrams for the production and decay of ϕ_R^0 .

3 Diphoton Signal

The diphoton signal cross-section, at the LHC for the proton center-of-mass energy \sqrt{s} , is given by,

$$\sigma(pp \rightarrow \phi_R^0 \rightarrow \gamma\gamma) = \frac{1}{m_{H_1} s \Gamma_{\text{tot}}} [c_{gg} \Gamma(\phi_R^0 \rightarrow gg)] \Gamma(\phi_R^0 \rightarrow \gamma\gamma), \quad (6)$$

where c_{gg} represents the parton integral,

$$c_{gg} = \frac{\pi^2}{8} \int_{m_{H_1}^2/s}^1 \frac{dz}{z} g(z) g\left(\frac{m_{H_1}^2}{zs}\right). \quad (7)$$

For $\sqrt{s} = 13$ TeV and $m_{H_1} = 750$ GeV, one can get c_{gg} to be ~ 2137 [18]. Now, within the 1σ error of CMS and ATLAS data the cross section $\sigma \in [3, 13]$ fb. In our analysis we use this range and calculate the allowed parameter space, consistent with this cross section measurement, allowed in our model. In this analysis we fix the mass of ϕ_R^0 , i.e., m_{H_1} at 750 GeV.

We compute the decay width $\Gamma(\phi_R^0 \rightarrow gg)$ with gluons, which has contribution from the new quark x , as shown in Fig. 1a. We also compute the $\Gamma(\phi_R^0 \rightarrow \gamma\gamma)$ decay width; the relevant diagrams are shown in Fig. 1b. The total ϕ_R^0 decay width is $\Gamma_{\text{tot}} = \Gamma(\phi_R^0 \rightarrow gg) + \Gamma(\phi_R^0 \rightarrow \gamma\gamma)$, since ϕ_R^0 does not have couplings with any SM fermions, W^\pm and Z . It couples to scalars $\Delta_R^{\pm/\pm\pm}$, but we assume the masses of these scalars in the range such that the decay of ϕ_R^0 to these scalars are kinematically forbidden. The contribution will come from x , W_R^\pm , Δ_R^\pm and $\Delta_R^{\pm\pm}$, see Fig. 1.

In this context we would like to mention the experimental constraints on the masses of W_R^\pm , Δ_R^\pm and $\Delta_R^{\pm\pm}$. In DLRM M_{Z_R} and $M_{W_R^\pm}$ are related as [63],

$$M_{W_R}^2 > \frac{(1 - 2s_w^2)}{2(1 - s_w^2)} M_{Z_R}^2 + \frac{s_w^2}{2(1 - s_w^2)^2} M_{W_L}^2, \quad (8)$$

where zero $Z - Z_R$ mixing is assumed. Z_R decays into SM fermions; $Z_R \rightarrow \ell^+ \ell^-$ have been reported by CMS (ATLAS) collaboration, which put $M_{Z_R} > 2.6$ TeV (2.9 TeV) [66]. After using Eq. 8, these bounds translate

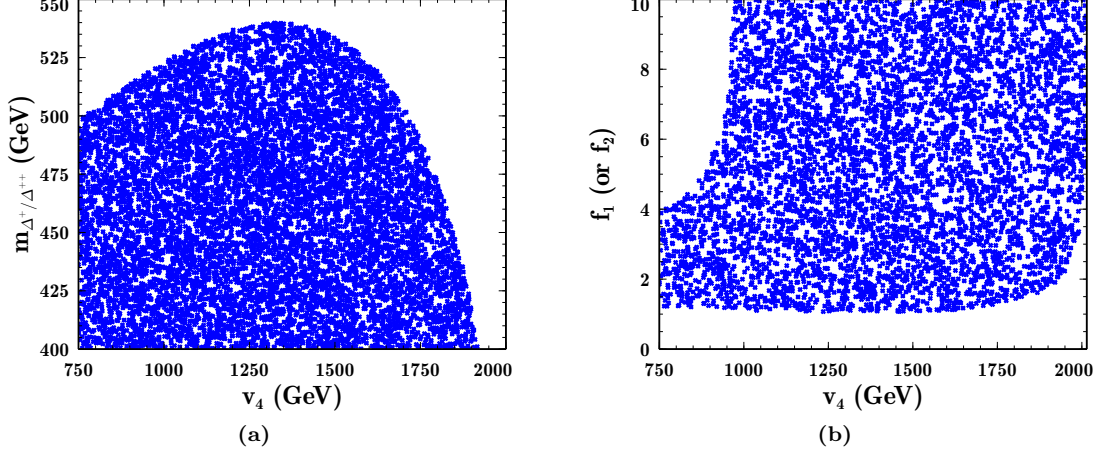


Figure 2: Allowed parameter space which results in the correct $pp \rightarrow \gamma\gamma$ cross section. We take $m_{W_R} = 1.8$ TeV and $g_R = 0.1$. In the left panel we show the allowed parameter space of the vev v_4 and the charged scalar masses. For simplicity we assume $f_1 = f_2 = 1$. The right panel shows the parameter region of v_4 and the quartic couplings f_1 and f_2 . We assumed $m_{\Delta_R^\pm} = m_{\Delta_R^{\pm\pm}} = 530$ GeV.

for W_R^\pm giving $M_{W_R} > 1.5$ TeV (1.7 TeV). The W_R^\pm diagram contributes with a negative sign, but by taking $M_{W_R} = 1.8$ TeV we find that W_R^\pm diagram has a smaller amplitude in compare to other diagrams of Fig. 1.

The doubly charged scalar ($\Delta_R^{\pm\pm}$) dominantly decays into same sign dileptons and is constrained by CMS (ATLAS) collaboration, which exclude $m_{\Delta^{\pm\pm}}$ below 445 GeV (409 GeV) and 457 GeV (398 GeV) for $e^\pm e^\pm$ and $\mu^\pm \mu^\pm$ channels respectively [67, 68]. The mass of singly charged scalar below 600 GeV (assuming 100% branching ratio in the $\tau\nu_\tau$ channel) is ruled out at 95% confidence level [69, 70]. But in DLRM model Δ_R^\pm not only couples with τ^\pm , but also with e^\pm and μ^\pm , so this bound is relaxed. In Fig. 2 we show the allowed parameter space of our model which gives $\sigma(pp \rightarrow \gamma\gamma) \sim 3 - 13$ fb, consistent with the observed diphoton signal cross section. In these plots we have taken $m_{\Delta_R^\pm} = m_{\Delta_R^{\pm\pm}}$ and $f_1 = f_2$. From the figures it is evident that $v_4 \gtrsim 1900$ GeV is not suitable for explaining the diphoton excess. For example, taking $f_1 = f_2 = 1$, $v_4 = 1.2$ TeV and $m_{\Delta_R^\pm} = m_{\Delta_R^{\pm\pm}} = 460$ GeV we found the $\sigma(pp \rightarrow \gamma\gamma) \sim 4.2$ fb which lies in the range of observed diphoton cross section; also for these set of parameters the decay width to gg is 1.9×10^{-3} GeV and to $\gamma\gamma$ is 1.2×10^{-3} GeV. Note that the 750 GeV scalar ϕ_R^0 , in this model, can also decay, via loop, to $Z\gamma$ and ZZ , but these decays are smaller than the diphoton decay by the factors $\sim 1/3$ and $1/9$ respectively and we have included these in our analysis. At this point it is worth-mentioning that this model can not reproduce the broad decay width mildly favoured by ATLAS data. In our subsequent calculation for dark matter relic density and muon ($g - 2$), we take $m_{\Delta_R^\pm} = m_{\Delta_R^{\pm\pm}} = 530$ GeV, which is consistent with the diphoton signal.

4 Dark Matter and muon ($g - 2$)

4.1 Dark Matter Relic Density

As an consequence of global symmetry S , the Yukawa term $\psi_L \tilde{\Phi} \psi_R$ is forbidden in DLRM, which basically connects ν_L with n_R . This implies that ν_L and n_R are not Dirac mass partner and the lightest n_R (out of three possible generation) can be identified as a viable dark matter candidate. We identify the second generation n_R (n_R^μ) as dark matter (we will call it χ), because then it can be related to the discrepancy of muon ($g - 2$). This idea is explored in detail in [65]. The mass of dark matter generates through the Yukawa term $\Psi_R \Psi_R \Delta_R$. We

assume that $m_{\Delta_R^\pm}$ is lighter in comparison to W_R^\pm, Z_R gauge boson masses. Therefore, the dominant annihilation of dark matter is given by a t -channel $\chi\chi \rightarrow \mu^+\mu^-$ through Δ_R^\pm .

After using the partial-wave expansion, the thermally averaged annihilation cross-section can be written as

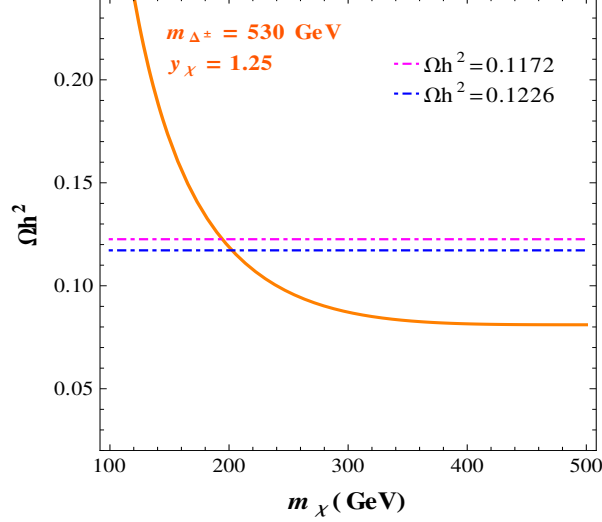


Figure 3: The relic abundance as a function of dark matter mass for $y_\chi = 1.25$ and $m_{\Delta_R^\pm} = 530$ GeV. The relic density experimental value $\Omega h^2 = 0.1199 \pm 0.0027$ [71] is shown by straight lines.

$\langle\sigma v\rangle \simeq a + 6b/x_f$, where a and b are the s and p -wave contributions respectively. The s -wave contribution is helicity suppressed and given as [72, 73],

$$a \simeq \frac{y_\chi^4}{32\pi m_\chi^2} \frac{m_f^2}{m_\chi^2} \frac{1}{(1+w)^2} \quad (9)$$

and the p -wave contribution is [74],

$$b \simeq \frac{y_\chi^4}{48\pi m_\chi^2} \frac{(1+w^2)}{(1+w)^4} \quad (10)$$

where m_f is the mass of the final state fermions and y_χ is the Yukawa type coupling between χ , μ^- and Δ_R^+ . Here the ratio of charged scalar mass with dark matter χ is defined as, $w = m_{\Delta_R^+}^2/m_\chi^2$. It is clear from Fig. 2, the allowed mass range of Δ_R^\pm from diphoton excess lies between ~ 400 GeV to 540 GeV. We take this bound into account and take $m_{\Delta_R^\pm} = 530$ GeV, $y_\chi = 1.25$ and compute the relic density. As shown in Fig. 3 that the correct relic density is obtained for a dark matter mass 200 GeV. As a result of dominant coupling of dark matter with Δ_R^\pm , DM annihilates into leptons, evading the stringent bounds from its direct detection search [75, 76].

4.2 Muon ($g-2$)

There exists a 3.6σ discrepancy between SM prediction and experimental value of muon ($g-2$) [77, 78]. In DLRM [63], there exist additional gauge bosons and charged triplet scalars which give contributions to the muon magnetic moment. As we mentioned before, there exist stringent bounds on the masses of $SU(2)_R$ gauge bosons (W_R^\pm, Z_R) from LHC, so the contributions of heavy gauge bosons to muon ($g-2$) will be small in comparison to the charged scalars. The relevant interactions term of muon ($g-2$) are $\psi_R\psi_R\Delta_R$ and $\psi_L\psi_L\Delta_L$. But $\psi_L\psi_L\Delta_L$ gives the mass to the neutrino and so have a small Yukawa coupling, whereas $\psi_R\psi_R\Delta_R$ does not have any restriction like this. So, we take into account only the contribution from $\Delta_R^\pm, \Delta_R^{\pm\pm}$ loops, as shown in

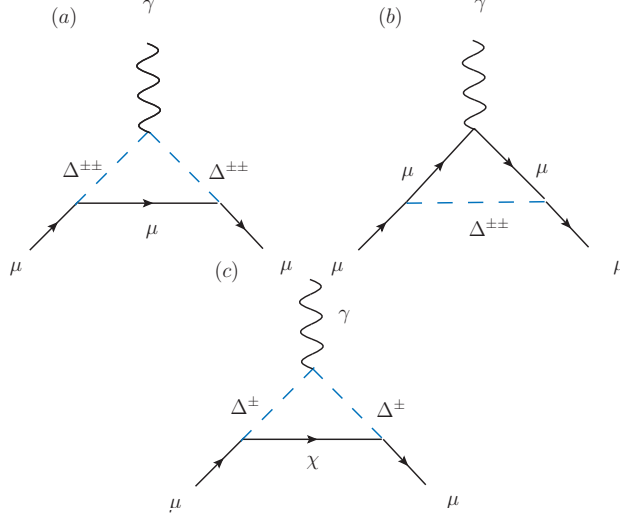


Figure 4: Dominant Feynman diagrams of doubly (a,b) and singly (c) charged triplet scalar loops contributing to muon ($g-2$).

Fig. 4.

The contribution from the doubly charged triplet higgs (as shown in Fig. 4(a)-4(b)) is given by [79],

$$[\Delta a_\mu]_{\Delta^{\pm\pm}} = 4 \times \left[\frac{2m_\mu^2}{8\pi^2} \int_0^1 dy \frac{f_{\mu s}^2(y^3 - y) + f_{\mu p}^2(y^3 - 2y^2 + y)}{m_\mu^2(y^2 - 2y + 1) + m_{\Delta^{\pm\pm}}^2 y} - \frac{m_\mu^2}{8\pi^2} \int_0^1 dy \frac{f_{\mu s}^2(2y^2 - y^3) - f_{\mu p}^2 y^3}{m_\mu^2 y^2 + m_{\Delta^{\pm\pm}}^2(1 - y)} \right] \quad (11)$$

where $f_{\mu s}$ and $f_{\mu p}$ are the scalar and pseudoscalar couplings of charged triplet higgs with the muon respectively. As a result of the interaction term $(\psi_R \psi_R \Delta_R)$ which has two identical fields, the symmetry factor of 4 is appeared in Eq. 11. The contribution from singly charged triplet higgs (Δ_R^\pm), which is shown in diagram 4(c), given as [79],

$$[\Delta a_\mu]_{\Delta^\pm} = \frac{m_\mu^2}{8\pi^2} \int_0^1 dy \frac{f_{\mu s}^2(y^3 - y^2 + \frac{m_\chi}{m_\mu}(y^2 - y)) + f_{\mu p}^2(y^3 - y^2 - \frac{m_\chi}{m_\mu}(y^2 - y))}{m_\mu^2 y^2 + (m_{\Delta^\pm}^2 - m_\mu^2)y + m_\chi^2(1 - y)} \quad (12)$$

The masses of the charged triplet scalars are fixed from the diphoton excess of LHC, which lies between $\sim 400 - 540$ GeV (see Fig. 2). We take $m_{\Delta^\pm} = m_{\Delta^{\pm\pm}} \sim 530$ GeV and use $f_{\mu s} = f_{\mu p} \simeq y_\chi = 1.25$ (this same value reproduces the correct relic density). We add all the contributions from Eq. 11 and Eq. 12, and finally obtain,

$$\Delta a_\mu = 2.99 \times 10^{-9}, \quad (13)$$

which is in agreement with the experimental result [77, 78] within 1σ . The connection between the dark matter and muon ($g-2$) in DLRM is also explored in [65] with details.

5 Summary and Conclusions

We explain the 750 GeV diphoton resonance observed by ATLAS and CMS in the context of the existing dark left-right model. A global symmetry in DLRM ensures the stability of dark matter. The same global symmetry

also ensures that the scalar particle identified as 750 GeV resonance can dominantly couple to the standard model gluons and photons. This explain the large branching of $\gamma\gamma$ and gg decay widths which is necessary to explain the diphoton cross-section. After fixing the parameters of the model to explain the diphoton cross-section, we compute the relic density of dark matter and muon ($g-2$) in this model and we show that a common explanation for all three is possible in DLRM. This explanation predicts a dark matter mass of 200 GeV. It would be interesting to see if future observations of dark matter and LHC will corroborate or rule out this model.

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